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Adaptation test of several plants under the Pine Forest stands

Mokhtar Effendi[1*], Yogi Sugito[2] and Agung Nugroho[2]

[1]Postgraduate Program, Faculty of Agriculture, Brawijaya University, Malang, **Indonesia**
[2]Department of Agronomy, Faculty of Agricultur Brawijaya University, Malang, **Indonesia**.

***Correspondence:** mokhtareffendi64@gmail.com **Accepted: 0**4 May 2019 **Published online:** 02 June. 2019

Utilization of land under stands is important, because agricultural development tends to lead to agricultural extension, namely by expanding agricultural land, the community can increase income without damaging the surrounding forest. UB Forest has a variety of stands, namely pine and mahogany, but most are obtained by pine by 90%, located at an altitude of 1,200 masl. In order to improve the usability of pine forests by using bounded land, it is hoped that there will be agricultural use that can be applied in this region without damaging the ecological sustainability of the area. The purpose of this research is to determine the extent to which plants are resistant to shade and look for opportunities for developing agricultural commodities that can be cultivated in the Pine Forest area. This research was conducted from September to December 2017. The experimental design used was a Nested Design with two factors, namely light intensity as a free factor and plant type as a non-free factor (nested in intensity). The light intensity factor consists of 3 levels, namely: Light Intensity of 400 Lux, Light Intensity of 800 Lux, and Light Intensity of 1200 lux. Factor Kinds of plant consist of mustard greens, leek, and cabbage.

Keywords: Agroforestry, Pine Forest, Shade, Light Intensity, Kind of Plant

INTRODUCTION

Forests are a natural place for flora and fauna, besides that forests also provide benefits for humans, because forest products can be used for various human needs. According to Soerianegara and Indrawan (2005) forests are a group of trees that are quite extensive and quite dense, so they can create their own micro-climate. Utilization of land under stands is important, because agricultural development tends to lead to agricultural extension, namely by expanding agricultural land, the community can utilize land under forest stands with agroforestry systems by planting seasonal crops to increase community income without damaging the surrounding forest. Agroforestry provides new hope for land management, and farmers must be supported to be able to use their natural resources sustainably at all times. The concept of agroforestry was first presented by a team from the Canadian International Developent Center (CIDA) when presenting the results of their assignments to identify priorities for tropical forestry research (Veer, 1981).

UB forest is an Education forest area managed by Brawijaya University through the Ministry of Environment of the Republic of Indonesia with Decree Number SK. 676 / Men LHK - Secretariat General / 2015 dated 31 December 2015 concerning the establishment of forest areas with specific objectives in protected forest areas and production forests (Sudarto et al., 2016). UB Forest has a variety of stands, namely pine and mahogany, but most are filled with pine by 90%, at an altitude of 1,200 masl. For increasing use of pine forests with land use under stands, it is expected that the use of agricultural commodities can be applied in the region without damaging the sustainability of the ecology of the area. Efforts to improve forest use and the development of sustainable agroforestry-based agricultural sectors require representative information related to the conditions of micro climates under forest stands. This information is useful to see the potential of suitable crops to be cultivated.

The purpose of this research is to study how many plants are resistant to shade and look for opportunities for agricultural development that can be cultivated in the pine forest area.

MATERIALS AND METHODS

This research was conducted in the UB Forest area located at the foot of Mount Arjuna in Sumbersari Village, Karangploso District, Malang Regency, East Java. Located at an altitude between ± 1200 masl and the temperature ranges from 22 ° C - 26 ° C. This research was conducted in September - December 2017. The experimental design used is a Nested Design with two factors, namely light intensity as a free factor and plant type as a non-free factor (nested in intensity). The light intensity factor consists of 3 levels, namely: Light Intensity of 400 Lux, Light Intensity of 800 Lux, and Light Intensity of 1200 lux. Factor kinds of plant consist of mustard greens, leek, and cabbage. Experimental plot measuring 150 x 150 cm with a spacing of 30 x 30 cm. The experiment was carried out three times and each plot consisted of twenty-five plants. The stages of this research are surveying the condition of UB Forest area, determining the location of planting, land preparation, planting, and maintenance of plants which include: irrigation, fertilization, weeding, and pest control.

Experiment Parameters

The observed variables consist of plant growth components which include:

a. Leaf area (cm^2 tan^{-1}) was observed using a leaf area meter
b. Crop growth rates

$$CGR = \frac{1}{GA} \text{ X } \frac{W_2 - W_1}{t_2 - t_1} (g/day^{-1})$$

(Sugito, 2013)

The yield component in the form of plant:

c. fresh weight, and
d. chlorophyll content

RESULTSAND DISCUSSION

Leaves are important organs for plants where photosynthesis takes place in the leaves. Number of Leaves and Area of Leaves are important parameters needed to determine the growth of a plant. Based on the growth graph in the figure, the number of leaves has increased from the age of 14 to 63 HST, at the age of observations 63 - 70 HST tend not to experience an increase in the number of leaves. Graphs of plant leaf growth can be presented in Figure 1.

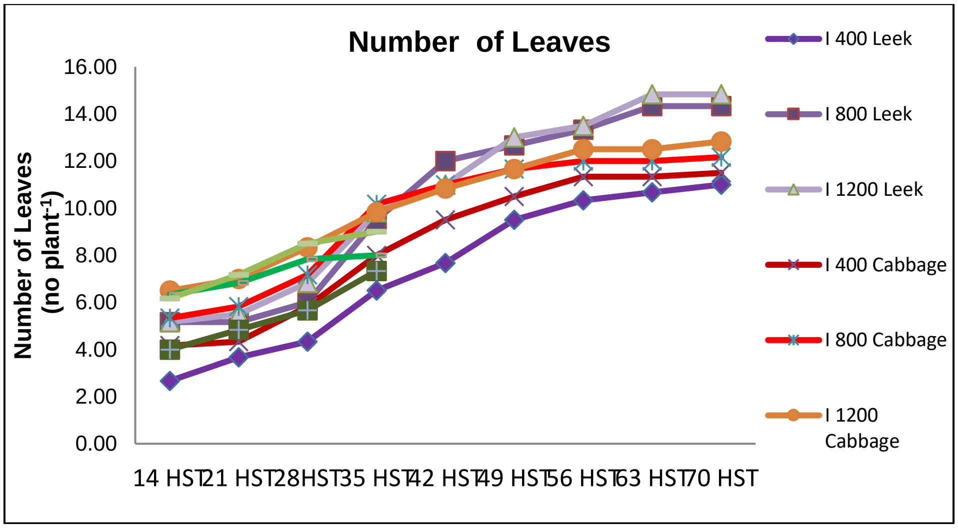

Figure 1. Graph number of leaves is due to the intensity of light st kinds of plant

The number of different leaves in each type of plant is very influenced by genetic traits and is slightly influenced by environmental factors. According to (Rahayu et al., 2010) the morphological differences will be obvious if planted in the same environment.

Leaf Area

The yield of leaf area is directly proportional to the number of leaves. The large number of leaves tends to produce large leaf area. The results of the variance analysis showed that observations of leaf area aged 28, 42 and 70 DAP had significant interactions between the treatment of light intensity and the types of plants presented in (Table 1). At the light intensity of 400 and 800 lux, cabbage produced a higher leaf area when compared to leek, but not significantly different when compared to mustard greens. At an intensity of 1200 lux cabbage produced the highest average leaf area compared to mustard greens and leek. This result is supported by the statement of Black and Ong (2000), the amount of radiation absorbed by plants is in line with the speed of initial growth and development of leaf area.

Leek produced a higher leaf area average at 1200 lux light intensity compared to 800 and 400 lux intensity. Cabbage at 1200 lux light intensity actually produced a higher leaf area than the light intensity of 400 lux but did not significantly produce the average leaf area compared to the light intensity of 800 lux. However, different things happen to mustard greens which have no real difference in producing leaf area at various light intensities. This is due to the adaptation of mustard greens to low light conditions, where the leaves of mustard plants are wider because of the anatomic changes in the leaves due to the influence of low light intensity, this is done for light perception by increasing the light capture area to increase leaf area per unit plant tissue. This is in line with Sutarmi's statement (1983), low light intensity will produce plants that have larger and thinner leaves, thin epidermal layer, little palisade tissue and wider cell space.

Crop Growth Rates

Plant growth rate is the ability of plants to produce dry weight assimilation results for each unit of land area per unit of time that is widely used in the analysis of the growth of cultivated plants in the field (Huang et al., 2016). The results showed that there was no interaction between light intensity and plant type on the growth rate parameters (Table 2).

At the first observation at 28-42 DAP plant growth rate of influence of 800 lux light intensity produced a plant growth rate of 0.001225 g $cm^2 day^{-1}$ which significantly increased the plant growth rate by 26.6% compared to the light intensity of 400 lux but not significantly different if compared to the intensity of 1200 lux. When viewed from the kinds of plant mustard greens produce a plant growth rate of 0,001413 g cm^2 day^{-1} is significantly higher when compared to leek and cabbage. However, in the second observation of plant growth rates 42 - 70 HST there was no significant difference between the treatment of light intensity. This is influenced by radiation as an important factor in plant metabolism. Theoretically the greater the amount of solar energy absorbed will increase the amount of photosynthesis (Zervoukdakis et al., 2012). In addition to the thick canopy, the received light intensity is low which causes low energy available to combine CO_2 and H_2O, this situation causes the rate of photosynthesis low, then naturally the plant growth rate will be low.

Fresh Weight

Components of growth will affect the components of a plant. The existence of a good growth phase, will be followed by a good generative phase in which the plant's generative organs will grow well and the plant is able to produce good results as well. Sunlight is a major component in producing biomass produced by plants (Oluwasemire and Odugbenro, 2014). The results of the variance analysis showed that there was a real interaction between the treatment of light intensity and the type of plant in observing the fresh weight of plants at all ages of observation, the main fresh weight of plants that have interactions is shown in (Table 3).

In this study the results were obtained for the fresh weight of plants presented in (Table 3) age of observation of 42 DAP of mustard greens at 1200 lux light intensity producing fresh weight 236.52 g tan^{-1} increased 36.2% compared to 400 lux intensity, but at 1200 lux light intensity did not significantly produce the fresh weight of plants compared to 800 lux light intensity. However, the leaves and cabbage were not significantly different in producing fresh weight of plants at various light intensities.

Table 1. Interaction between light intensity and kinds of plant to Leaf Area (cm² plant⁻¹) of Plants at 28, 42 and 70 DAP

Observation Period 28 DAP	Treatment Light Intensity	Leaf area (cm² plant⁻¹) Kinds of Plant: Mustard Greens	Leek	Cabbage
	400 Lux	1116,48 b	153,65 a	1259,11b
	800 Lux	1426,69 bc	170,72 a	1564,61bc
	1200 Lux	1089,69 b	155,32 a	1917,53c
HSD 5%		582,76		
CV (%)		20,40		
	Treatment	Kinds of Plant		
42 DAP	Light Intensity	Leek		Cabbage
	400 Lux		282,19 a	1986,40 c
	800 Lux		466,20 ab	1813,33 c
	1200 Lux		869,57 b	2007,38 c
HSD 5%		473,99		
CV (%)		19,78		
	Treatment	Kinds of Plant		
70 DAP	Light Intensity	Leek		Cabbage
	400 Lux		478,05 a	1449,51 b
	800 Lux		605,87 a	1946,68 c
	1200 Lux		1081,13 b	2114,10 c
HSD 5%		431,81		
CV (%)		17,36		

Note : Numbers with the same lowercase letters in the same row and the same upper case in the same column show not significant difference in HSD test (P<0.05), DAP = days after planting

Table 2. Crop growth rate (g cm² day⁻¹) of Plants due to Treatment of Light Intensity and Kinds of Plant at 28 – 42, dan 42 – 70 DAP

Treatment	Crop Growth Rate (g cm² day⁻¹) Observation Period (DAP): 28 – 42	42 – 70
Light Intensity		
Light Intensity 400 Lux	0,000898 a	0,000255
Light Intensity 800 Lux	0,001225 b	0,000222
Light Intensity 1200 Lux	0,001456 b	0,000222
HSD 5 %	0,000177	tn
Kinds of Plant		
Mustard Greens	0,001413 b	
Leek	0,000836 a	0,000386 b
Cabbage	0,001329 a	0,000314a
HSD 5 %	0,000177	0,000066
CV (%)	22,98	31,9

Note : Numbers with the same lowercase letters in the same row and the same upper case in the same column show not significant difference in HSD test (P<0.05), DAP = days after planting

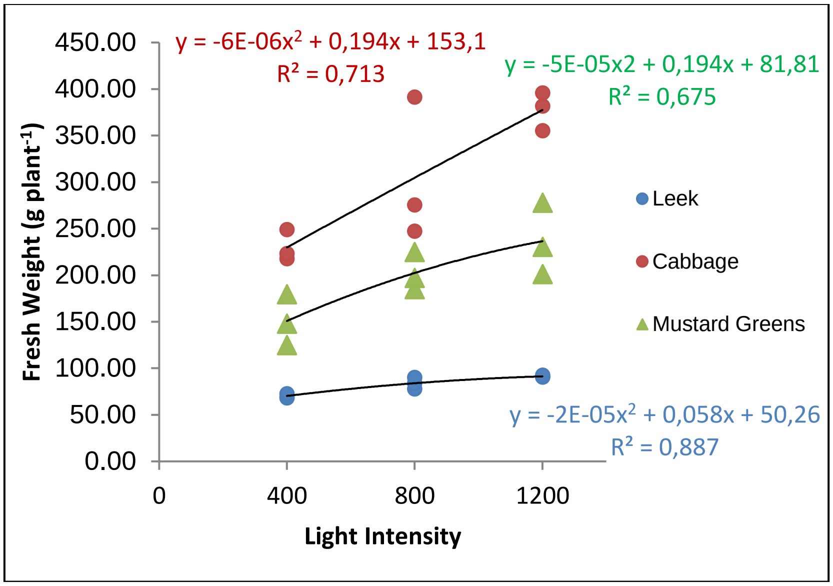

Figure 2.The effect of light intensity and kinds of plants toward total fresh weight.

At the observation age of 70 DAP of cabbage there was also an increase in the fresh weight of plants at 1200 lux light intensity, increasing by 39% compared to 400 lux light intensity but not significantly different from yielding fresh plant weights compared to 800 lux light intensity. Increased light has a positive effect on increasing crop production.

This is supported by the statement of Widiastuti et al., (2004) that the intensity of light that causes less photosynthesis rate decreases, so that the results of photosynthesis can be disrupted by respiration, food reserves are reduced so that plant growth can be hampered. To see the extent of the relationship between Light Intensity (X) to the fresh weight (Y) of the three types of plants, a regression analysis was performed (Figure 2).

Regression analysis for cabbage showed that there was a relationship between productivity and light y = -6E-06x2 + 0.194x + 153.1 R^2 = 0.713, while for leek the regression equation was y = -2E-05x2 + 0.058x + 50.26 R^2 = 0.887 and for Mustard greens the regression equation is y = -5E-05x2 + 0.194x + 81.81 R^2 = 0.675. R2 is the coefficient of determination, for the coefficient of determination on cabbage 0.713, leek 0.887 and mustard 0.675 which are interpreted to be around 71%, 88% and 67.5% of fresh weight produced in cabbage, leek, and mustard greens by light intensity.

chlorophyll

The measurement of chlorophyll content in leaves was carried out using a spectrophotometer with a wavelength of 646 nm to measure the chlorophyll B and 663 nm content to measure the chlorophyll content A. Analysis of the content of chlorophyll a, b and total chlorophyll was carried out by the Arnon method (1949). The results of the analysis of the variety of chlorophyll content are presented in (Table 4).

At 1200 lux light intensity the highest chlorophyll content was significantly higher by 15.69% compared to 800 light intensity and significantly higher by 31.54% compared to 400 lux. While the 800 light intensity was 18.8% higher resulting in chlorophyll content compared to the light intensity of 400 lux. While the type of mustard plants produced the highest average chlorophyll content compared to leaf onion and cabbage plants. Leaves onion plants did not significantly produce chlorophyll compared to cabbage plants.

The decrease in light intensity due to shade will reduce the chlorophyll a / b ratio, due to the increase in the relative amount of chlorophyll b compared to chlorophyll a. Niinemets (2010), states that low-light-tolerant plant species in shade conditions will increase chlorophyll content higher than sensitive. The greater chlorophyll content in the genotype group is happy to allow plants to get more light energy which can then be processed into chemical energy in the form of excited electrons.

Table 3. Interaction between light intensity and kinds of plant to Fresh Weight (g plant^{-1}) of Plants at 28, 42 and 70 DAP

Observation Period	Treatment Light Intensity	Fresh Weight (g tan^{-1})		
		Kinds of Plant		
28 DAP		**Mustard Greens**	**Leek**	**Cabbage**
	400 Lux	60,77 b	21,93 a	23,93 a
	800 Lux	75,78 b	31,66 a	32,80 a
	1200 Lux	101,48 c	31,43 a	31,23 a
HSD 5%		23,31		
CV (%)		17,57		
	Treatment	Kinds of Plant		
42 DAP	Light Intensity	Mustard Greens	Leek	Cabbage
	400 Lux	150,83 de	35,83 a	89,25 bc
	800 Lux	202,40 ef	41,55 ab	86,52 abc
	1200 Lux	236,52 f	43,87 ab	99,62 cd
HSD 5%		52,90		
CV (%)		16,62		
	Treatment	Kinds of Plant		
70 DAP	Light Intensity	Leek		Cabbage
	400 Lux		70,28 a	229,93 b
	800 Lux		83,97 a	304,72 bc
	1200 Lux		91,32 a	377,50 c
HSD 5%		78,20		
CV (%)		20,93		

Note : Numbers with the same lowercase letters in the same row and the same upper case in the same column show not significant difference in HSD test (P<0.05), DAP = days after planting

Table 4. Measurement of Chlorophyll (μm fresh weight $^{-1}$) of Plants due to Treatment of Light Intensity and Kinds of Plant

Treatment	Chlorophyll content (μm fresh weight $^{-1}$)
Light Intensity	
Light Intensity 400 Lux	8,55 a
Light Intensity 800 Lux	10,53 b
Light Intensity 1200 Lux	12,49c
HSD 5 %	1,75
Kinds of Plant	
Mustard Greens	12,83 b
Leek	8,68 a
Cabbage	10,05 a
HSD 5 %	1,75
CV (%)	25,83

Note : Numbers with the same lowercase letters in the same row and the same upper case in the same column show not significant difference in HSD test (P<0.05), DAP = days after planting

CONCLUSION

It can be concluded from this study that the light intensity of 800 lux was able to increase growth in the parameters of leaf number, leaf area and plant growth rate compared to the light intensity of 400 lux.

Cabbage plants are considered more adaptive cultivated in pine forests, because they are able to adapt to low light intensity.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Mokhtar Effendi is the lead author who conducts research in the field, Prof. Dr. Ir. Yogi Sugito is the second author and lead counselor then Dr. Ir.

Agung Nugroho, MS the third author and as the second guide in reviewing the manuscript.

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